View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Elsevier - Publisher Connector

Morphologic Manifestations and Urethral Function in Female Lower Urinary Tract Symptoms: Correlation between Ultrasonographic and Urodynamic Studies

Jenn-Ming Yang, Wen-Chen Huang[1] and Su-Jau Yang[2]

Purpose: The aim of this study was to evaluate the morphologic features of female lower urinary tract symptoms and to examine the association between morphologic characteristics and urethral function.

Materials and Methods: The records of 1,341 women with lower urinary tract symptoms and one single urodynamic diagnosis were reviewed. These include 560 subjects with genuine stress incontinence, 130 with detrusor instability, 78 with mixed incontinence, 89 with hypersensitive bladder, 144 with voiding difficulty and 340 with negative findings on urodynamic studies. Thirty-six female volunteers with no symptoms associated with the lower urinary tract served as controls. All had ultrasonography to assess morphologic changes of the lower urinary tract qualitatively and quantitatively.

Results: Hypersensitive bladder and control groups had significantly higher bladder neck position during stress, lesser rotational angle of the bladder neck, lower incidence of bladder neck funneling and cystocele formation, and lesser bladder wall thickness at the dome than did the other diagnostic groups, except for the incidence of bladder neck funneling in the voiding difficulty group. Excluding the incidence of cystocele development and bladder neck funneling, morphologic manifestations of female lower urinary tract symptoms did not vary with urodynamic diagnosis, except for hypersensitive bladder. Functionally, there was a significant difference in all parameters of urethral function among different diagnostic groups, except functional profile length. Micturition resistance was associated with resting bladder neck angle and bladder neck funneling (p = 0.004 and 0.034, respectively). Pressure transmission ratio at 1st quartile of the urethra was associated with cystocele (p = 0.004). Bladder wall thickness at the trigone was directly associated with maximum urethral closure pressure as well as pressure transmission ratios, and indirectly, with cystocele. Bladder wall thickness at the dome was associated with

Received: August 29, 2002. Accepted: September 30, 2002.
Division of Urogynecology, Department of Obstetrics and Gynecology, Mackay Memorial Hospital, Taipei Medical University, Taipei, Taiwan; [1]Department of Obstetrics and Gynecology, Cathay General Hospital, Taipei, Taiwan; and [2]Department of Pediatrics, Baylor College of Medicine, Houston, Texas.
Address correspondence and reprint requests to: Dr. Jenn-Ming Yang, 92 Chung-Shan North Road, Section 2, Taipei, 10449, Taiwan.

maximum urethral closure pressure and detrusor opening pressure (p = 0.004 and 0.046, respectively).

Conclusions: Ultrasonography may provide another way to explore the pathophysiology of female lower urinary tract symptoms.

(*J Med Ultrasound* 2002;10:126–134)

KEY WORDS: • lower urinary tract symptoms • ultrasonography • urodynamics

Introduction

Abacteriuric lower urinary tract symptoms (LUTS) are present in a heterogeneous group of disorders with varied pathogeneses. Because urinary symptoms are diagnostically unreliable [1], it is appropriate to use urodynamic and imaging studies as an integral part of the evaluation of lower urinary tract disorders. Currently, videocystourethrography is a tool that simultaneously offers both urodynamic and anatomic assessments of the lower urinary tract. Nonetheless, it is not widely available because of its sophistication and concerns about radiation exposure. Ultrasonography, which is noninvasive, reproducible and without radiation, has replaced radiological methods in the anatomic evaluation of the lower urinary tract [2–5]. Associations between ultrasonographic features and urodynamic findings have been reported for genuine stress incontinence (GSI) [2–4] and detrusor instability (DI) [6]. Hypermobility, together with descent of the bladder neck and urethra, are common imaging findings in GSI [2–5]. Impairment of pressure transmission to the bladder neck and proximal urethra is the corresponding manifestation in functional studies [7]. However, some patients with GSI do not have obvious hypermobility of the bladder neck. The pathogenesis of GSI in these cases has been attributed to an intrinsic sphincter defect, i.e., a dysfunction of the urethra. DI is highly associated with increased bladder wall thickness secondary to detrusor hypertrophy [5]. Urethral obstruction, whether intrinsic or extrinsic, is one of the pathogenic factors of DI.

Alteration of the anatomy of the lower urinary tract may result in functional disorders and *vice versa*. When the urethra, the urinary conduit and controller of continence in the lower urinary tract, dysfunctions, it may incite urinary symptoms and subsequently induce morphologic change in the lower urinary tract. The aims of this study were: 1) to reveal the morphologic features in women with abacteriuric LUTS, based on urodynamic and ultrasound imaging studies; and 2) to elucidate the association between morphologic characteristics and urethral function.

Materials and Methods

Subjects

We retrospectively reviewed the records of our urogynecologic clinics from August 1996 to March 2001. Female patients with LUTS (frequency, nocturia, urgency, obstructive voiding, or urinary incontinence) for at least 3 months and who had undergone functional evaluation of lower urinary tract by urodynamic study, together with morphologic assessment of lower urinary tract by ultrasonography, were identified. Exclusion criteria in this study included all of the following: 1) history of pelvic surgery, neuropathy (central or peripheral) or diabetes mellitus; 2) symptoms of hematuria, recurrent dysuria or infection on urine culture; and 3) urodynamic study resulting in two or more diagnostic entities.

Ultrasonography

Ultrasonographic cystourethrography was performed with patients in a supine position, with a comfortably full bladder, using transvaginal ultrasound with a Toshiba SSA-260A scanner (Tokyo, Japan) and a 5.0 MHz vaginal probe. Morphology of the lower urinary tract was evaluated at rest and during a maximum Valsalva maneuver. These included measurement of the bladder neck position (Fig. 1) and observation of the development of funneling of the bladder neck, opening of the proximal urethra (Figs. 2A–C), and formation of a cystocele, prolapse or herniation of the bladder base below the urethrovesical

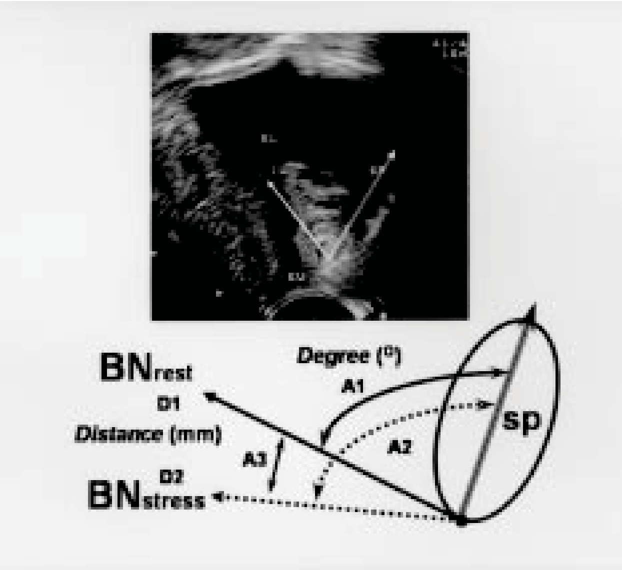

Fig. 1. *Parameters measured during ultrasonographic cystourethrography. The position of the bladder neck (internal urethral orifice, IU) was measured using the distance of the bladder neck to the lower border of the pubic symphysis and the angle between the bladder neck-symphyseal line and the midline of the pubic symphysis. sp = pubic symphysis; EU = external urethral meatus; BL = bladder; BNrest = bladder neck position at rest; BNstress = bladder neck position during stress; A1 = bladder neck angle at rest; A2= bladder neck angle during stress; A3 = rotational angle of the bladder neck (A3= A2–A1); D1 = bladder neck-symphyseal distance at rest; D2 = bladder neck-symphyseal distance during stress.*

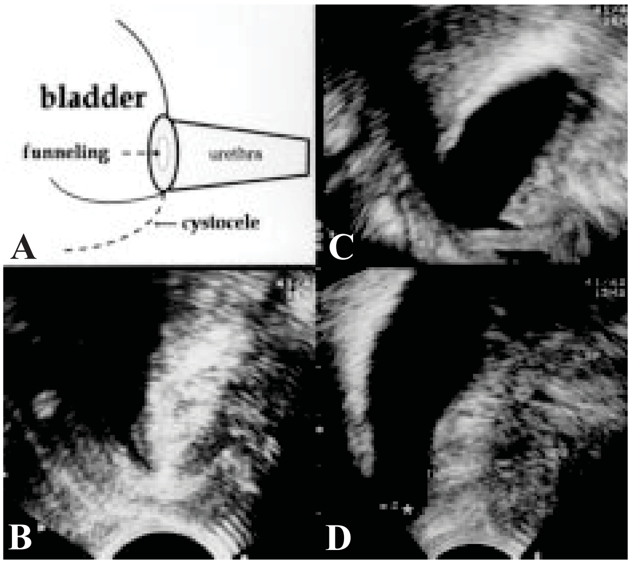

Fig. 2. *Qualitative analysis of the bladder neck and bladder base during stress (compared with Fig. 1). A) Schematic diagram indicating the anatomic changes in bladder neck funneling and cystocele formation. B) Funneling of the bladder neck (opening of the internal urethral orifice, IU) with a vertical descent (sliding along the urethral axis) during stress. C) Funneling with a rotational descent (posterior-inferiorly downward rotation) of the bladder neck during stress. D) Development of a cystocele (*) during stress. sp = pubic symphysis; EU = external urethral meatus.*

junction (Figs. 2A and D). The motion of the bladder neck during the Valsalva maneuver may be a sliding descent along the urethral axis (vertical descent) (Fig. 2B) or a posterior-inferiorly downward descent, with the lower border of pubic symphysis as the pivot (rotational descent) (Fig. 2C). The images were frozen at rest and at maximum Valsalva for the measurement of bladder neck position. Two lines were drawn: one was drawn between the lower border of the pubic symphysis and the bladder neck (internal urethral orifice), and the other was the midline of the pubic symphysis, with a starting point at the lower border of pubic symphysis (Fig. 1). The position of the bladder neck was quantified using the distance of the bladder neck to the lower border of the pubic symphysis and the angle between the bladder neck-symphyseal line and the midline of the pubic symphysis [8]. Both angle and distance were measured electronically by an internal program housed in the ultrasound equipment. Rotational angle was defined as the difference of the angle between resting and straining bladder neck positions. Bladder wall thickness at the trigone and dome were measured at rest after the bladder was emptied (Fig. 3). One author (JMY) performed all ultrasonographic cystourethrography.

Urodynamics

Urodynamic studies included spontaneous uroflowmetry, filling and voiding phase cystometry and urethral pressure profiles on both resting and straining. Cystometry was performed at a filling rate of 80 mL/min with the patient seated upright in a birthing chair. The intravesical pressure was measured with a fluid-filled catheter (4.5 F), and the intra-abdominal pressure was measured transrectally with a latex rectal catheter. A voiding study was performed with the bladder filled to the maximum cystometric capacity, the patient in the seated position and the catheters still in place. Static and stress urethral pressure profiles were obtained with

Fig. 3. *Measurement of bladder wall thickness at the trigone (T) and dome (D). sp = pubic symphysis; U = urethra.*

the patient sitting at 45°, at a maximal cystometric capacity. Data were recorded continuously on a MMS UD-2000 (Medical Measurement Systems, Enschede, Netherlands) multichannel recorder.

Based on the results of the urodynamic study, the functional disorders were categorized into six groups: GSI, DI, mixed incontinence (MI), hypersensitive bladder (HB), voiding difficulty (VD) and negative findings (NE) on urodynamic study. GSI was diagnosed if the patient had symptoms of stress incontinence and had observable leakage produced by stress without concurrently demonstrable detrusor activity during cystometry. DI was diagnosed if the patient had a detrusor contraction in association with urgency and/or leakage. MI was diagnosed if patients had criteria for both GSI and DI. HB was diagnosed if the first desire to void occurred at less than 100 mL and the maximum cystometric capacity was less than 300 mL of infused saline in the presence of a stable detrusor [9]. VD was diagnosed if the maximum flow rate was less than 15 mL/s for patients under 60 years of age and less than 10 mL/s for patients over 60 years or the presence of more than 100 mL of residual urine on two or more readings [10, 11]. MI was regarded as a single entity, although it was made up of two diagnostic criteria.

Urethral function was evaluated based on parameters selected from the static and stress urethral pressure profile as well as pressure-flow studies: maximum urethral closure pressure (MUCP), functional profile length (FPL), detrusor opening pressure ($P_{det.op}$), intravesical opening pressure ($P_{ves.op}$), micturition resistance and pressure transmission ratios at the 1st and 2nd quartiles of the urethra (Q_1 & Q_2). All terminology conforms to International Continence Society usage except when specifically mentioned [12].

Statistical analysis

All analyses were conducted using SPSS 10.0 for Windows (SPSS Inc, Chicago, IL). Descriptive statistics for measured variables were calculated for the overall sample and for each study group. Analysis of variance was used to test for differences among study groups for continuous, measured variables. Multiple comparisons were conducted using the Scheffe test if means were significantly different among study groups. To test the distribution of the discretely measured variables among study groups, the Chi-square test was used. General linear model and Spearman rank correlation (rho) test were used to examine the associations between ultrasonographic characteristics and explanatory variables, controlling for age, parity, menopause and type of bladder disorder. *P*-values of less than 0.05 were considered significant.

Results

There were 1,341 subjects included in the study group. These included 560 patients with a diagnosis of GSI, 130 with DI, 78 with MI, 89 with HB, 144 with VD and 340 with NE. The mean age for the study groups was 48 ± 13 years (range, 20–87 years), the mean gravidity was 4.0 ± 2.4 (range, 0–21) and the mean parity was 2.9 ± 1.7 (range, 0–12). Of the 1,341 subjects, 502 (37%) were postmenopausal. Another 36 female volunteers of the same age, gravidity, and percentage in menopause as the study group were recruited from the gynecologic clinic to serve as controls. The controls all denied a history of urogenital tract dysfunction or major pelvic surgery and underwent ultrasonographic evaluation of the lower urinary tract and pelvis. Tables 1 and 2 display the demographics and morphologic features, respectively, of the control and study groups. The HB group was significantly younger, had the lowest parity and the fewest postmenopausal women than did the control and other diagnostic groups.

Table 1. Demographic data for the control and study groups

	Controls	Genuine stress incontinence	Detrusor instability	Mixed incontinence	Hypersensitive bladder	Voiding difficulty	Negative findings
Number of patients	36	560	130	78	89	144	340
Age (years)†	48 ± 12[a]* (16–83)	48 ± 11[a,b] (26–85)	55 ± 17[b] (20–87)	53 ± 14[a,b] (32–80)	40 ± 10[c] (20–61)	47 ± 14[a,b] (20–83)	47 ± 14[a,b] (20–73)
Gravidity†	4.0 ± 2.4[a] (0–20)	4.2 ± 2.1[a] (0–15)	4.6 ± 3.5[a] (0–21)	4.3 ± 1.9[a] (0–10)	2.8 ± 1.7[b] (0–6)	3.2 ± 2.4[a] (0–11)	3.9 ± 2.3[a] (0–10)
Parity†	3.0 ± 1.8[a] (0–12)	3.0 ± 1.4[a] (0–9)	3.3 ± 2.3[a] (0–12)	3.2 ± 1.5[a] (0–6)	2.1 ± 1.5[b] (0–6)	2.5 ± 1.9[a] (0–11)	2.9 ± 2.0[a] (0–8)
Menopause‡	14[a,d] (39)	162[ac] (29)	62[b,d] (48)	38[b,d] (49)	17[c] (19)	50[a] (35)	173[b] (51)

*Different superscript letters indicate significant mean differences ($p < 0.05$).
†Data presented as mean ± standard deviation (range). ANOVA was used to test the mean difference.
‡Data presented as n (%). The chi-square test was used to test the equality of distributions.

Table 2. Ultrasonographic data for the control and study groups

	Controls	Genuine stress incontinence	Detrusor instability	Mixed incontinence	Hypersensitive bladder	Voiding difficulty	Negative findings
Resting bladder neck							
Angle (°)†	81 ± 15[a] (59–117)	98 ± 23[b] (34–192)	96 ± 25[b] (60–178)	99 ± 22[b] (53–144)	87 ± 24[a,b] (70–137)	94 ± 21[b] (56–159)	100 ± 28[b] (48–179)
Distance (mm)†	25.7 ± 4.9 (15.4–32.1)	24.9 ± 5.5 (9.9–37.9)	24.3 ± 4.5 (15.0–34.8)	24.6 ± 5.0 (13.7–37.0)	22.6 ± 5.5 (18.5–29.1)	24.1 ± 5.5 (10.0–42.0)	23.5 ± 4.7 (10.1–34.4)
Straining bladder neck							
Angle (°)†	113 ± 27[a] (78–175)	154 ± 33[b] (86–235)	144 ± 35[b] (74–207)	141 ± 27[b] (96–219)	113 ± 24[a,c] (87–145)	139 ± 37[b] (56–201)	145 ± 38[b] (80–224)
Distance (mm)†	22.9 ± 3.3 (15.9–28.1)	21.4 ± 5.6 (9.9–37.9)	21.3 ± 4.5 (15.0–31.0)	23.2 ± 7.2 (13.9–38.2)	20.8 ± 2.6 (15.8–22.6)	21.0 ± 6.2 (9.0–44.0)	22.9 ± 6.4 (10.7–42.0)
Rotational Angle (°)†	30 ± 20[a] (1–58)	56 ± 29[b] (1–145)	44 ± 32[b] (1–120)	42 ± 23[b] (1–92)	26 ± 25[a,c] (2–75)	46 ± 34[b] (1–123)	45 ± 32[b] (1–143)
Cystocele‡	2[a] (6)	234[b] (42)	35[e,f] (27)	17[c,f] (22)	0[a]	38[c,d,e] (26)	120[b,d,e] (28)
Bladder neck funneling‡	0[a]	198[b] (35)	20[c] (15)	22[b,d] (28)	0[a]	8[a] (6)	74[c,d] (22)
Bladder wall thickness							
At trigone (mm)†	5.0 ± 1.3[a] (2.0–6.8)	5.7 ± 1.9[b] (2.0–15.0)	5.5 ± 1.5[a,b] (3.0–8.0)	5.5 ± 1.9[a,b] (2.0–10.0)	4.8 ± 2.0[a] (2.0–7.6)	6.0 ± 1.8[b] (3.0–10.0)	6.2 ± 2.2[b] (3.0–12.0)
At dome (mm)†	4.7 ± 0.9[a] (3.1–6.3)	6.0 ± 3.2[b] (2.0–12.0)	5.7 ± 2.2[b] (3.0–10.0)	5.5 ± 1.9[b] (3.0–10.0)	4.4 ± 1.9[a] (3.0–7.0)	6.1 ± 2.1[b] (3.0–12.0)	6.0 ± 2.3[b] (3.0–13.0)

*Different superscript letters indicate significant mean differences ($p < 0.05$).
†Data are presented as mean ± standard deviation (range). ANOVA was used to test the mean differences.
‡Data presented as n (%). The chi-square test was used to test the equality of distributions.

Ultrasonographic manifestations

When compared with controls, each LUTS diagnostic group had significantly lower bladder neck positions at rest and during stress, greater rotational angle, higher incidence of bladder neck funneling and cystocele formation, and increased mean bladder wall thickness, except for the HB group. Furthermore, there was no difference in the incidence of bladder neck funneling between the controls and VD group. The increased mean bladder wall thickness was mainly due to the increase in bladder wall thickness at the dome. Subjects with urodynamic diagnoses of GSI, VD and NE had, in addition, an increase in bladder wall thickness at the trigone.

When compared with other diagnostic groups, the HB group had significantly higher bladder neck positions during stress, lesser rotational angle, lower incidence of bladder neck funneling and cystocele formation, and lesser mean bladder wall thickness, except for the incidence of bladder neck funneling in the VD group. Excluding the incidence of cystocele formation and bladder neck funneling, morphologic manifestations of female LUTS did not vary with different urodynamic diagnoses, except HB. The presence of cystocele formation or funneling of the bladder neck was significantly associated with a lower bladder neck position at rest and during stress, as well as a greater rotational angle. Nevertheless, there was no association between the presence of cystocele formation and bladder neck funneling (p = 0.109).

Urethral function in different groups

There was a significant difference in all parameters of urethral function among the different diagnostic groups except for FPL (Table 3). Higher MUCP was noted in the HB group. The VD group had higher values of $P_{ves.op,}$ $P_{det.op}$ and micturition resistance than

Table 3. Urethral function in the study groups

	Genuine stress incontinence	Detrusor instability	Mixed incontinence	Hypersensitive bladder	Voiding difficulty	Negative findings
Maximum urethral closure pressure (cmH_2O)	64 ± 27[c]* (21–157)	67 ± 24[a,c] (25–139)	56 ± 20[c] (20–83)	87 ± 35[c] (23–236)	77 ± 24[a] (27–128)	71 ± 29[a] (20–236)
Functional profile length (cm)	3.0 ± 2.2 (1.6–5.5)	3.1 ± 0.7 (1.4–7.1)	2.8 ± 0.6 (1.1–5.0)	3.3 ± 1.0 (1.8–5.2)	3.1 ± 0.6 (1.4–5.0)	3.1 ± 1.3 (1.6–6.0)
Intravesical opening pressure (cmH_2O)	48 ± 18[a] (15–112)	54 ± 18[b,c] (24–107)	54 ± 30[a.b.c] (28–160)	49 ± 17[a.b] (17–102)	59 ± 28[c] (23–216)	48 ± 15[a,b] (25–111)
Detrusor opening pressure (cmH_2O)	21 ± 11[a] (1–58)	31 ± 15[b,c] (9–83)	30 ± 24[b,c] (3–93)	29 ± 15[c] (10–86)	37 ± 22[b] (4–113)	24 ± 11[a,c] (1–53)
Micturition resistance ($cmH_2O/(mL/s)^2$)	0.24 ± 1.33[a] (0.02–19.8)	0.26 ± 0.27[a,b] (0.04–1.38)	0.32 ± 1.16[a,b] (0.02–5.56)	0.53 ± 0.91[a,b] (0.04–4.92)	0.60 ± 0.57[b] (0.01–2.53)	0.24 ± 0.54[a,b] (0.02–4.56)
Q1 (%)	99 ± 29[a] (2–241)	106 ± 33[a,b] (22–288)	100 ± 30[a,b] (32–200)	112 ± 33[b] (43–212)	104 ± 32[a,b] (1–200)	106 ± 31[a,b] (8–275)
Q2 (%)	96 ± 35[a] (1–375)	107 ± 34[a,b] (29–243)	98 ± 36[a,b] (10–212)	106 ± 33[a,b] (1–262)	106 ± 41[a,b] (1–212)	109 ± 58[b] (6–200)

Data presented as mean ± standard deviation (range). ANOVA was used to test the mean differences. Q1 = pressure transmission ratio at the 1st quartile of the urethra; Q2 = pressure transmission ratio at the 2nd quartile of the urethra. *Different superscripts indicate significant mean differences.

Table 4. Association between ultrasonographic features and urethral function parameters in the study groups

	Maximum urethral closure pressure	Functional profile length	Micturition resistance	Intravesical opening pressure	Detrusor opening pressure	Q1	Q2
Resting bladder neck angle	r = 0.251 SE = 0.204	r = 0.022 SE = 0.004	r = 0.285† SE = 0.008	r = 0.030 SE = 0.102	r = 0.015 SE = 0.080	r = 0.035 SE = 0.001	r = 0.016 SE = 0.001
Straining bladder neck angle	r = 0.239 SE = 0.160	r = 0.034 SE = 0.003	r = 0.094 SE = 0.005	r = 0.127 SE = 0.067	r = 0.099 SE = 0.049	r = 0.074 SE = 0.0001	r = 0.035 SE = 0.001
Rotation angle of bladder neck	r = 0.326 SE = 0.163	r = 0.05 SE = 0.003	r = 0.106 SE = 0.006	r = 0.166 SE = 0.075	r = 0.123 SE = 0.058	r = 0.076 SE = 0.001	r = 0.053 SE = 0.001
Cystocele	r = 0.212 SE = 12.727	r = –0.023 SE = 0.045	r = –0.042 SE = 0.102	r = 0.004 SE = 0.094	r = 0.127 SE = 0.099	r = 0.152† SE = 0.054	r = –0.003 SE = 0.058
Bladder neck funneling	r = 0.324 SE = 10.015	r = –0.012 SE = 0.044	r = –0.211* SE = 0.098	r = –0.037 SE = 0.095	r = –0.111 SE = 0.095	r = 0.053 SE = 0.054	r = –0.079 SE = 0.055
Bladder wall thickness at trigone	r = 0.337* SE = 1.725	r = 0.085 SE = 0.048	r = 0.126 SE = 0.094	r = 0.023 SE = 1.182	r = 0.070 SE = 0.862	r = 0.203‡ SE = 0.009	r = 0.169† SE = 0.017
Bladder wall thickness at dome	r = 0.442† SE = 1.402	r = 0.006 SE = 0.033	r = 0.059 SE = 0.082	r = 0.105 SE = 1.020	r = 0.202* SE = 0.732	r = 0.047 SE = 0.006	r = 0.081 SE = 0.013

Data were analyzed by general linear models or Spearman rank correlation (rho) test.
*$p < 0.05$, †$p < 0.01$ and ‡$p < 0.0001$.
Q1 = pressure transmission ratio at the 1st quartile of the urethra; Q2 = pressure transmission ratio at the 2nd quartile of the urethra; r = Pearson or Spearman correlation coefficient; SE = standard error of the slope.

did the GSI group. Table 4 displays the associations between ultrasonographic features and the urethral function parameters. Micturition resistance was associated with resting bladder neck angle and bladder neck funneling (p = 0.004 and 0.034, respectively). Q1 was associated with the development of cystocele (p = 0.004). Bladder wall thickness at the trigone was directly associated with MUCP and pressure transmission ratios, and indirectly with cystocele. Bladder wall thickness at the dome was associated with MUCP and $P_{det.op}$ (p = 0.004 and 0.046, respectively).

Discussion

Several methods have been used for the quantitative analysis of the lower urinary tract on ultrasonography. In this study, we measured the motility of the urethrovesical junction by two parameters [8], the bladder neck-symphyseal distance and the rotational angle of the urethrovesical junction. We believe these parameters are appropriate to describe the rotational and vertical descent of the bladder neck seen during real-time ultrasonography [4]. Assessing the angle change during bladder neck motion not only reveals the severity of hypermobility but also provides the clinical significance associated with the dynamic change of the bladder neck [13]. Urethral thickness and posterior urethrovesical angle are two common parameters used to analyze the lower urinary tract, but we used neither in this study. The former is affected by menopause [6, 14] and the latter lacks reproducibility [15], making them weak indicators of lower urinary tract function.

Of the 1,341 subjects with LUTS, 48% (638) had GSI, whether alone or mixed with DI. Reviewing the literature, we found that morphologic studies of the lower urinary tract focused intensively on GSI.

Serial reports describe the change in urethral angles, bladder neck funneling and location of the urethrovesical junction at the most dependent point of the lower urinary tract as the morphologic features of GSI [2–5]. We also found a significantly higher incidence of cystocele formation and increased thickness of the bladder wall in GSI in our subjects when compared with controls. These morphologic characteristics are not specific for GSI. When compared with controls, morphologic manifestations similar to those seen in GSI were found in all other LUTS diagnostic categories except for HB. The differences among study groups excluding HB were a higher incidence of cystocele development and bladder neck funneling in GSI. It has been reported that parity seems to be a primary prerequisite for the presence of bladder neck funneling [5]. In our study, the HB and VD groups had lower parity and lower incidence of bladder neck funneling.

Cystocele formation demonstrated distinct progression on ultrasonography. A ballooning cystocele is the most dependent part of the lower urinary tract and might exert various effects, depending on its severity [16–18]. It may dissipate intravesical pressure, pull down and kink the urethra or compress the proximal urethra, all of which may cause significant changes on urodynamic study.

In contrast to a previous report [6], increased bladder wall thickness was not a unique feature to DI in our study. The pathogenesis of thickened bladder wall is multifactorial. Bladder wall thickness may increase secondary to the increase of MUCP. Increase of $P_{det.op}$, a measure of extraluminal-intramural type of urethral obstruction [19, 20], may particularly increase bladder wall thickness at the dome. A cystocele is another factor associated with a thickened bladder wall [6]. A cystocele may aggravate urethral dysfunction by external compression of the urethrovesical junction and its neighboring area and result in elevated pressure transmission ratios. Elevated pressure transmission ratios are specifically associated with bladder wall thickness at the trigone and may indicate an extramural type of urethral obstruction [21]. In our study, GSI, VD and NE groups had higher incidences of cystocele formation and increased bladder wall thickness at the trigone. Therefore, a thickened bladder wall in a different area may imply a specific type of urethral obstruction. This may explain why obstructive symptoms may be found in subjects with GSI. The dynamic effect of a cystocele together with urethral axis distortion may convert urinary incontinence to the continent state or even to voiding difficulty in subjects with NE or VD (Fig. 4). A thickened bladder wall is associated with symptoms of urgency after Burch colposuspension [13]. We postulate that a thickened bladder wall may be associated with some urinary symptoms in those with NE. Urethral resistance, an indicator of intraluminal type of urethral obstruction, is not associated with bladder wall thickness but with resting bladder neck position. In this study, we did not measure the thickness of anterior bladder wall because of its fluffy image on ultrasonography. The anterior bladder wall is shaded by the acoustic

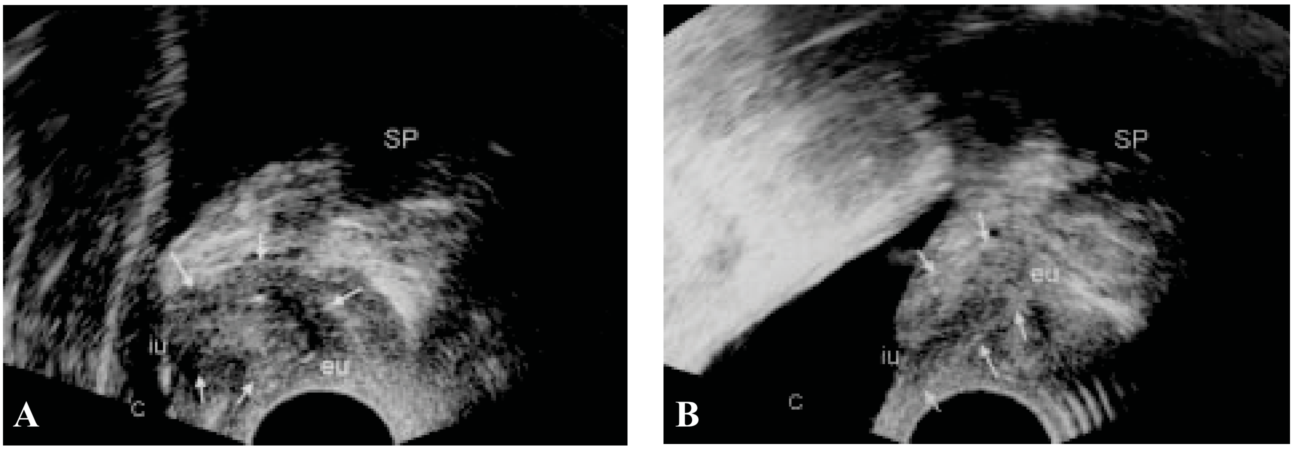

Fig. 4. *Ultrasonographic cystourethrography displaying hypermobility of the bladder neck with development of a cystocele (c) during the Valsalva maneuver in cases of voiding difficulty (A) and genuine stress incontinence (B). Kinking of the urethra (arrows) was noted in A when compared with the image of B. sp = pubic symphysis; BL = bladder; eu = external urethral meatus; iu = internal urethral orifice.*

shadow from the pubic symphysis, making measurement inaccurate.

Most subjects with LUTS had morphologic changes such as hypermobility of the bladder neck and a thickened bladder wall. The HB group was the exception, and a number of these patients studied with cystourethroscopy had specific changes characteristic of this disorder. Moreover, the demographics of the HB group were significantly different from those of other diagnostic groups. This implies that the pathogenesis of HB is different from other disorders causing LUTS. The former may arise from a lesion in the urothelium and the latter is a consequence of pelvic floor relaxation. While surgical intervention for some disorders in some subjects with LUTS may cure, or at least improve, urinary problems by correction of anterior vaginal wall defects and relief of urethral obstruction, it might not be suitable in all cases, for example in HB because of its different pathogenesis.

In conclusion, based on our study, ultrasonography provides another way to explore the pathophysiology of female LUTS.

References

1. Jensen JK, Nielsen FR Jr, Ostergard DR. The role of patient history in the diagnosis of urinary incontinence. *Obstet Gynecol* 1994;83:904–9.
2. Mouritsen L, Strandberg C. Vaginal ultrasonography versus colpo-cysto-urethrography in the evaluation of female urinary incontinence. *Acta Obstet Gynecol Scand* 1994;73:338–42.
3. Demirci F, Fine PM. Ultrasonography in stress urinary incontinence. *Int Urogynecol J Pelvic Floor Dysfunct* 1996;7:125–32.
4. Petri E, Koelbl H, Schaer G. What is the place of ultrasound in urogynecology? A written panel. *Int Urogynecol J Pelvic Floor Dysfunct* 1999;10:262–73.
5. Schaer GN, Perucchini D, Munz E, et al. Sonographic evaluation of the bladder neck in continent and stress-incontinent women. *Obstet Gynecol* 1999;93:412–6.
6. Khullar V, Cardozo LD, Salvaore S, et al. Ultrasound: a non-invasive screening test for detrusor instability. *Br J Obstet Gynaecol* 1996;103:904–8.
7. Walters MD, Newtorn ER. Pathophysiology and obstetric issues of genuine stress incontinence and pelvic floor dysfunction. In: Walters MD, Karram MM, eds. *Urogynecology and Reconstructive Pelvic Surgery.* 2nd ed. St. Louis: Mosby, 1999:135–44.
8. Mouritsen L, Rasmussen A. Bladder neck mobility evaluated by vaginal ultrasonography. *Br J Urol* 1993;71:166–71.
9. Ramsay IN, Ali HM, Hunter M, et al. A randomized controlled trial of urodynamic investigation prior to conservative treatment of urinary incontinence in the female. *Int Urogynecol J Pelvic Floor Dysfunct* 1995;6:277–81.
10. Stanton SL, Ozsoy C, Hilton P. Voiding difficulties in the female: prevalence, clinical and urodynamic review. *Obstet Gynecol* 1983;61:144–7.
11. Lose G, Jorgensen L, Mortensen SO, et al. Voiding difficulties after colposuspension. *Obstet Gynecol* 1987;69:33–8.
12. Abrams P, Blaivas JG, Stanton SL, et al. The standardization of terminology of lower urinary tract function recommended by the International Continence Society. *Int Urogynecol J Pelvic Floor Dysfunct* 1990;1:45–58.
13. Martan A, Masata J, Halaska M, et al. Ultrasound imaging of the lower urinary system in women after Burch colposuspension. *Ultrasound Obstet Gynecol* 2001;17:58–64.
14. Yang JM. Factors affecting urethrocystographic parameters in urinary continent women. *J Clin Ultrasound* 1996;24:249–55.
15. Schaer GN, Koechlil OR, Schuessler B, et al. Perineal ultrasound for evaluating the bladder neck in urinary stress incontinence. *Obstet Gynecol* 1995;85:220–4.
16. Ghoniem GM, Walters F, Lewis V. The value of the vaginal pack test in large cystocele. *J Urol* 1994;152:931–4.
17. Cosimo O, Pierluigi P, Angelo ZM, et al. A clinical and urodynamic study of patients with varying degrees of cystocele. *Maturitas* 1997;27:125–32.
18. Yalcin OT, Yildirim A, Hassa H. The effects of severe cystocele on urogynecologic symptoms and findings. *Acta Obstet Gynecol Scand* 2001;80:423–7.
19. Griffiths DJ. Pressure-flow studies of micturition. *Urol Clin North Am* 1996;23:279–97.
20. Vowles JE, Wagg AS. The pressure-flow plot in the evaluation of female incontinence. *Br J Urol* 1999;84:948–52.
21. Bump RC, Fantl JA, Hurt WG. The mechanism of urinary continence in women with severe uterovaginal prolapse: results of barrier studies. *Obstet Gynecol* 1988;72:291–5.